BC PARKS FOUNDATION

Community-based monitoring toolkit

How to start a simple, cost-efficient community-based monitoring program in British Columbia, Canada

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We recognize and acknowledge that we live, work, and are in relation with people across many traditional and unceded territories covering all regions of British Columbia, who were the original caretakers and stewards of the lands and waters.

If you're reading this toolkit because you're interested in stewarding or taking care of a nature area, welcome! Community-based stewardship, including monitoring, is a core component of BC Parks Foundation's strategy to Protect vital nature areas Now, so that we can Enjoy them Forever. In 2022, the BC government announced its intention to protect 30% of the land and water by 2030, in line with the UN Convention of Biological Diversity global goal that was ratified by 188 governments in Montreal in December 2022. As of December 2023, terrestrial conserved area in BC totaled 185,896 km^2, 19.7% of BC's land area[1]. These vast areas contain incredible habitat and biological diversity, but little is known about them, with many areas remaining unsurveyed. It would be impossible for the small group of scientists working in BC to cover all conserved areas, even as biodiversity and ecological data are critically needed for effective conservation and management.

This brings us to community-based monitoring. Community scientists such as yourself have a major role to play in nature stewardship. By crowdsourcing nature observations and monitoring-data collection, the impossible becomes possible—we can build a comprehensive, province-wide biodiversity database to fill information gaps, including in remote areas. With community-sourced data that are collected in a consistent, standardized manner, researchers and conservation practitioners can ensure that the protected status conferred on a nature area is working, that sensitive habitats and threatened species are thriving or recovering from previous disturbances, and that early warning of impacts from major events such as climate change, wildfire, and flooding can be received, enabling timely responses.

Monitoring is done to keep track of the "health" of a nature area or check that things are okay, ecologically speaking. Here, we'll go through the basics of monitoring through the lens of a non-scientist, including how to set up a simple monitoring program; considerations for data storage, analysis, and interpretation; and how to use the results to help inform decision making and manage a nature area.

1. Introduction to monitoring

1.1 WHO IS THIS TOOLKIT FOR?

First, we want to emphasize that it is possible to carry out monitoring even with very limited resources. This toolkit is for anyone who is interested in keeping tabs on the status of a nature area or wildlife population in their community; a science background is optional. We will focus on low- to moderate-budget options for survey gear and materials, less labor-intensive methods with simple metrics, and uncomplicated data analysis. For more involved monitoring, particularly in Indigenous-managed nature areas, the Indigenous Guardians Toolkit is a comprehensive resource and highly recommended. Another great resource to look at is the IUCN's framework for biodiversity monitoring.

Even with simple, free or low-cost tools, it is possible to gather useful and highly informative data. If simple surveys are repeated over time, monitoring is achieved. The far-reaching goal is to build up a long-term database to enable trends assessment. It may be tempting to monitor several indicators or employ a complex, overly broad survey design to be more scientifically robust, but without an equally robust supply of funding and skilled labor, these programs tend not to last long. Importantly, in addition to being cost-effective and sustainable, a well-thought-out monitoring program should include community participation and data that feed into conservation and management decisions, such as recording data in systems accessible to protected area managers. These aspects will be discussed further in the next sections.

[1] https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/conserved-areas.html

1.2 WHAT IS MONITORING?

There are many types of monitoring, and it is done for various purposes, but within the context of nature area management, monitoring is essentially the repeated collection and analysis of information about a particular place or multiple places over time, to allow for the detection of changes in biodiversity and/or habitats over time. Often, other information is recorded that enables the determination of whether any change observed is significant and probable causes of that change. Monitoring may be confused with surveys. The concepts are similar, as biodiversity counts and assessments (i.e., surveys) commonly take place during monitoring. However, monitoring has a time component – think of monitoring as a series of the same surveys repeated on a regular basis[2].

A one-off biodiversity survey, i.e., a biological inventory, provides important baseline information but is not monitoring. Nevertheless, this information is useful for future comparisons, mapping out sensitive habitats and species, and establishing a zoning plan in a protected area. If resources are available, an inventory is still recommended at the start of a monitoring program.

1.3 WHY MONITOR?

One of the main long-term goals of managing a significant nature area or protected area is to ensure that the biodiversity and ecosystem functions of this area will be sustained in perpetuity. With monitoring, broadly speaking, data are collected regularly for informing habitat and resource management, especially the decision making associated with such management. Carefully designed monitoring activities can also increase levels of connection, engagement, and stewardship within local communities[3].

It is difficult to measure ecosystem "health" or overall function directly. To track these attributes, representative measures (i.e., indicators; more on that in Section 3.2) are assessed and recorded instead. These could be the population size of a species of interest, habitat or landscape features such as the percentage of land covered by forest, and abiotic indicators such as the level of oxygen in a water body. Thus, in **surveillance monitoring**, the abundance (number of individuals, usually in a given area) of a target species can be counted yearly and compared to the baseline number to ensure that the population, and by extension, the habitat, is doing well. This can include assessments of how well the target species recovers from natural events such as wildfires, droughts, and floods. In **implementation monitoring**, we are interested in whether a planned intervention has the desired effect. This is very much a before-and-after comparison. For example, monitoring the cover of invasive and native plant species to determine whether an invasive species removal plan is working.

[2] https://www.denix.osd.mil/biodiversity/ch-8/ecosystems/index.html

[3] Werner FA, Gallo-Orsi U (2016) Biodiversity Monitoring for Natural Resource Management – An Introductory Manual. GIZ, Eschborn and Bonn, Germany. DOI: 10.13140/RG.2.1.3141.8488/1

How does having all these data inform management decision making, though? Here are some simple scenarios to illustrate the process. If, over time,

- The target species population remains stable compared to baseline or increases (i.e., recovers) after a major disturbance, then it's business as usual, and no additional actions are needed;
- The target species population declines, then it would be prudent to understand the reasons for the decline and take action to slow or halt the decline;
- The invasive plant species being removed is eradicated in the project location (say, after 2 years) and the cover of replanted native vegetation is increasing, then the removal project appears to be meeting its targets, and the protected area manager can consider expanding the removal project to other parts of the protected area.

2. Pre-monitoring considerations

2.1 HABITAT OVERVIEW

Before mapping out your monitoring plan, get to know your nature area. If you haven't done so yet, visit in person; walk the trails or paddle the waterways. Go when there's life to observe – that can be spring to fall to view vegetation in forests, shrubland, or grassland, and at low tides for marine intertidal habitats. Find and read as many scientific and non-scientific reports on the area as you can. Gather local ecological knowledge by talking to people who spend a lot of time in the area, including Indigenous elders, amateur naturalists, hunters, and fishermen. You don't need to be a taxonomic expert on all species in your nature area, but you should know broadly which ecosystems can be found here, what the main species of interest are, and if any seasonal patterns (e.g., bird breeding, salmon spawning) exist. It is also useful to know what activities (e.g., recreation, hunting, development, etc.) are taking place in the area, including other monitoring programs (see next section)!

2.2 COORDINATE EFFORTS AND SEEK AUTHORIZATION

Importantly, find out who the protected area management authorities or organizations are and whether similar monitoring or data-collection efforts are happening in your area. For parks and many conservation areas, you should reach out to the relevant management authorities to work out a partnership or access agreement before doing any planning. Ideally, some sort of coordination should take place across existing efforts, and any additional monitoring should help fill knowledge or data gaps, rather than replicate what is already occurring. For example, if regular vegetation surveys are already taking place and you're interested in monitoring invasive plants, instead of launching new surveys, ask whether the surveyors can also note the presence and condition of any invasive species spotted. If surveys are only being conducted on the western side of a nature area, discuss with the organizers the possibility of expanding the survey program to the eastern side, so as to cover the whole area.

2.3 BUDGET

Key considerations are whether funding is available for monitoring, whether there is an income source, and how sustainable the funding will be. If you have start-up funding, but future funding is not certain, you may want to pick a survey protocol that can be deployed without much cost and spend the initial funds on a one-time purchase of equipment and materials that you will reuse in subsequent surveys. For example, buying binoculars and bird guidebooks that can be loaned out for annual bird counts, and having volunteers walk a set route while counting birds and recording observations on the eBird app on their mobile phones in each survey. With a very small budget (or none), it's better to keep surveys as simple as possible, without heavy reliance on expensive equipment and materials to be provided by the survey organizer. In this case, you may wish to recruit participants who already have the required equipment, e.g., binoculars, mobile phone with a camera, etc.. Some low-budget survey options will be discussed in the "Designing a monitoring protocol" section (Section 3.3).

2.4 PARTICIPANT RECRUITMENT AND RETENTION

Together with finding a sustainable source of funding, participant recruitment and retention is probably the major challenge in establishing a monitoring program. Think about participant pools from which you can draw a steady supply of monitoring volunteers for at least 5 to 10 years. Monitoring partners are definitely helpful in this respect. Regarding things to consider, if each year brings a new group of participants (e.g., school students), the survey needs to be simple enough that not much training or previous knowledge is needed for participants to go out and start collecting data. Other considerations include the time availability of volunteers and their capabilities. For example, activities may have to be restricted to weekends and evenings for volunteers working or studying full-time, and the difficulty of site access and level of physical exertion required for the activity should match participant capabilities.

Potential participant pools:

- Partner with local-area nature clubs, conservation groups, and youth groups with an established volunteer base
  - o This is especially useful if member recruitment is happening on a regular basis. For youth groups, find out if there is a Canada Service Corps program running in your area
- Partner with local schools and universities
  - o Consider reaching out to science teachers about adopting the nature site as a fieldwork site for their students and incorporating surveys into their lesson plans
- Reach out to groups who can provide "free data" for monitoring based on their regular activities
  - o E.g., people who hunt and fish, hikers, nature photographers
  - o A best practice approach is to check in with the local Fish and Wildlife staff who issue hunting and fishing licences to ensure surveys align with the work they are doing
  - o Data can be collected through hunting and fishing questionnaires or by asking people recreating to complete a short survey or submit photographs from fixed photo stations
  - o Be prepared for lots of outreach, and participants are more likely to share if they understand how the survey information would be used and their privacy respected (e.g., participants are anonymous)
  - o A robust data-handling system needs to be established (more on that in Chapter 4)
- Recruit participants from the general public
  - o This mode of recruitment is well-suited to simple, crowdsourcing-type data collection using apps such as iNaturalist and CrowdWater
  - o For example, Parks Canada and the University of Windsor run a photo station-based program for coastline monitoring called Coastie
  - o Lots of public outreach and regular advertising (e.g., on social media) are needed to engage this participant pool.

A note on remote areas: It is understandably very challenging to recruit monitoring volunteers in remote areas with a small population. For monitoring such areas, avoid labor-intensive survey methods, and look into remote-sensing data collection or methods that don't require extensive time in the field. This can include simple analysis of satellite imagery, remote camera deployment, and environmental DNA (eDNA) sampling. "Free data" may be a possibility too, if your area is frequented by trip outfitters, hunters, boaters, etc.

3. The Nuts and Bolts of Monitoring

3.1 SET YOUR OBJECTIVES EARLY

A major pitfall that leads to the demise of many monitoring programs is "directionless" monitoring, notably, the collection of several types of data on as many attributes as possible that culminates in a struggle at the analysis stage to interpret the data, or worse, the realization that the data do not address the main concerns of the project. This type of data collection tends to result in volunteer burnout and is an inefficient use of limited resources. We recommend instead that you have a clear vision for what you want to monitor and why at the very beginning. Usually, this is related to the status of the ecosystem or specific taxa, with monitors wanting to ensure that the protected area is doing well. It is useful to pose research questions based on the monitoring objectives (see below for examples), and any data collected then relate directly to answering the research questions.

Surveillance monitoring – research questions are commonly based on trends over time, as follows:

- Is the canopy cover (%) of a forest (representing forest status)…
    - o Similar to the cover during a pre-disturbance period
    - o Meeting a target cover, or
    - o Above a minimum cover?
- Is the abundance of a species of interest (e.g., number of frogs in a pond)…
    - o Staying the same
    - o Increasing, or
    - o Decreasing on a year-to-year basis?

Implementation monitoring – these types of research questions are simpler to craft; the main question is whether there is a difference in the attribute of interest before and after an intervention, as follows:

- Did the area covered by invasive plant species decrease after an invasive plant removal work party? Is the invasive plant cover decreasing over time?
- Did the survival of native trees improve after fencing to prevent deer browsing?
- Did the hatch rate of juvenile salmon improve after signs were put up asking people not to step in streams during the spawning season?

Because you want the data collected to be useful, identify at this stage the decision makers that important information should go to and think about how you might respond to changes in habitat/taxon status based on the monitoring data. For example, if the abundance of a threatened plant species is decreasing because it is being trampled by visitors, you might decide to fence off the area and put up signs educating visitors about the species. Subsequently, it would be good to conduct additional monitoring to see if the plant status improves.

3.2 SELECTING INDICATORS

Habitat and species we are interested in tracking. Some features are not measurable, such as the "health" or overall ecological functioning of an ecosystem. However, we can measure parts of the ecosystem that relate to, or indicate, its overall well-being. For a forest ecosystem, that can include forest cover, the proportion of diseased trees, and the proportion and growth rate of trees over a certain diameter. Indicators should be **simple to measure and analyze** and be **informative**, i.e., data collected on selected indicators must answer research questions or address monitoring objectives. Check this before proceeding with data collection. Quantitative data can be captured for nonquantitative indicators by assigning ranks or scoring on a scale, such as assessing a tree recovering from disease as being in poor, fair, good, or excellent condition (more details on this in Section 3.3). Numbers make analysis much easier, as you can plot data in charts or compare scores from year to year rather than trying to extract and compare information from blocks of text.

Indicators can be selected based on habitat type and taxa of interest, as follows. First, identify the main habitat(s) in the area you are monitoring. Next, consider the habitat type(s).

Habitat type:

- Habitats with water (freshwater and marine), e.g., lakes, rivers/creeks, intertidal, estuaries
    - o Consider water-quality indicators, including nutrient levels, water clarity, and oxygen levels, among others
    - o For creeks and streams, the water level and presence of running water
- Terrestrial and aquatic habitats with dominant vegetation, e.g., forests, kelp, seagrass
    - o Vegetation-related indicators such as cover and density
- Aquatic habitats with dominant bottom-dwelling (benthic) organisms, e.g., coral reefs, oyster reefs, mussel beds
    - o Organism cover, density
- Habitats including human developments, e.g., urban parks, agricultural areas, forestry areas
    - o Landscape indicators including land-use/land-cover (LULC) proportions, e.g., the percentage of developed vs. undeveloped area

Then, for each habitat, determine if the following taxa are present.

Identifying taxa of interest:

- Habitat-forming taxa
    - o For a forest, these would be the forest trees, with dominant tree species or large trees selected as taxa of interest
    - o Similarly, kelp forest → kelp, seagrass bed → eelgrass
- Taxa that are very important ecologically (i.e., keystone species). Some examples below
    - o River system or watershed: salmon, because they feed a variety of animals and transport nutrients from the sea to the forest as they migrate to spawn
    - o Kelp forest: sea otters, because they manage the sea urchin population and prevent urchins from overgrazing kelp
    - o Intertidal habitat: ochre sea stars, because they eat mussels, thus preventing mussels from overgrowing other marine life and establishing a monoculture
- Focal taxa (taxa that attract attention or are of great concern)
    - o Charismatic species such as bald eagles and large mammals
    - o Species of cultural importance, such as caribou and traditional food plants
    - o Species at risk, including endangered and threatened species
    - o Invasive species such as scotch broom and English ivy

- o Species at risk, including endangered and threatened species
- o Invasive species such as scotch broom and English ivy

From the overall list of habitat-forming, keystone, and focal taxa, select the target taxa for monitoring considering the monitoring objectives and any funding, time, and resource limitations. Once the taxa of interest have been determined, here's some guidance for how to derive indicators based on taxa (i.e., what to measure)

- Taxa for which it is difficult to pick out individuals or that are highly numerous, e.g., vegetation in a landscape, seaweed, benthic animals, colonial animals
    - o Percentage cover by area or points (Fig. 1)
- Taxa for which individuals can be counted fairly easily
    - o Density (abundance per unit area)
    - o Total abundance, if the area monitored is fixed and the same area is surveyed each time
    - o Density/abundance based on certain characteristics, e.g., the number of large individuals (trees, mussels, etc.) in the habitat, or the number of juvenile vs. adult eagles

Indicators other than cover or abundance

- Taxa that may be hard to count (e.g., well camouflaged) or rare, e.g., many mammals
    - o Number of species observed, i.e., species richness
    - o Types of species observed
- Non-moving taxa such as trees
    - o Growth rate
- Birds
    - o Nest abundance, nest productivity (i.e., whether the nest was used to raise chicks)

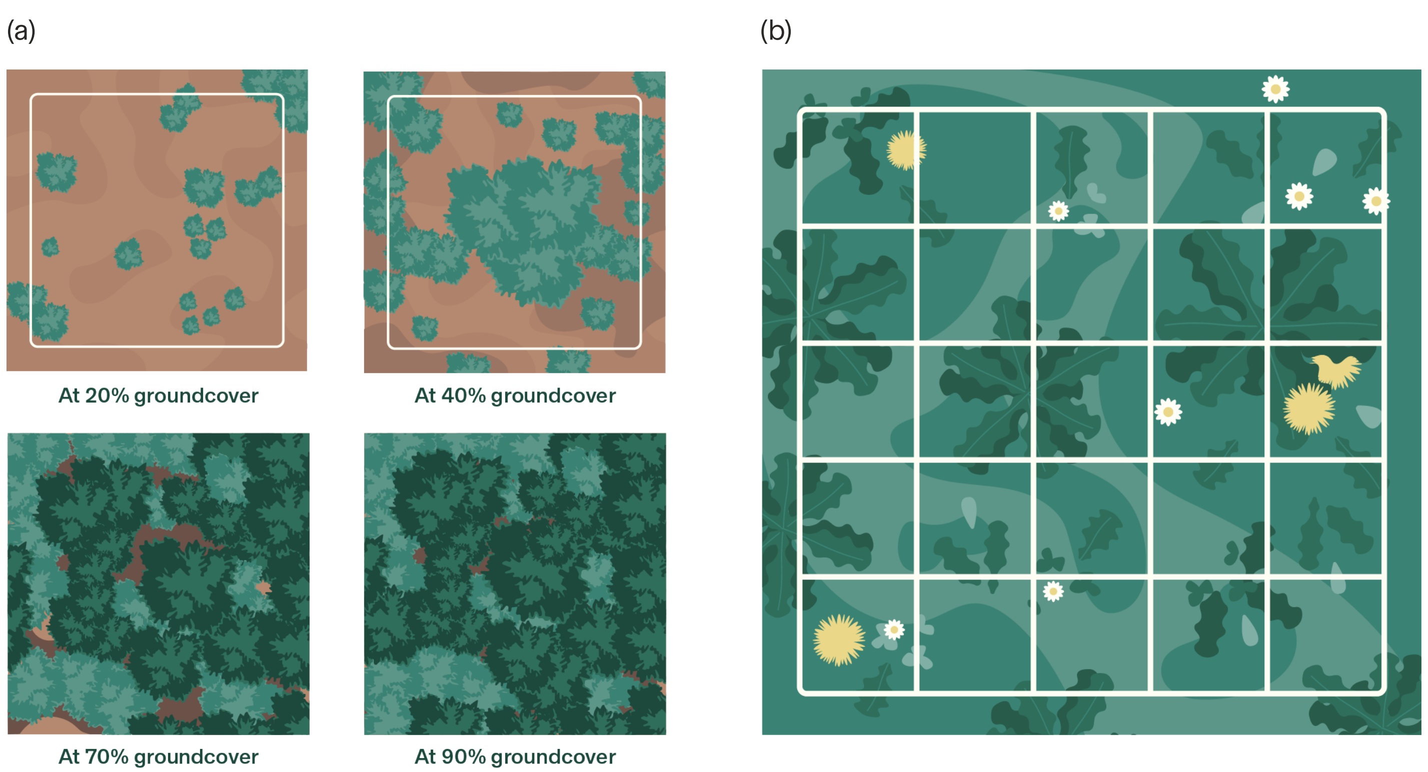


Fig. 1 (a). Estimating ground vegetation percentage cover within a quadrat, typically using an image analysis tool. (b) With a grid, percentage cover can also be estimated by counting the number of square containing the target taxon or the number of line intersections (points) directly above targeted individuals (image from Mrs Smith's Biology).

3.3 DESIGNING A MONITORING PROTOCOL

3.3.1 FIRST, HOW TO TAKE MEASUREMENTS

Now that the indicators have been selected, we can look at designing protocols for data collection. A major consideration here is the budget, most of which would go toward survey gear, transport to/from the field site, and allowances for volunteers. Many monitoring protocols for the indicators mentioned above have been established, so much so that we acknowledge it can be overwhelming to go through the various options available. What we recommend, as you assess different protocols, are survey methods that are simple to set up and easily repeatable (thus, you are able to use the same protocol over time) without excessive or expensive gear requirements. Better still if the method was developed by an established organization with a broad reach and used widely by community groups, such as eBird's checklist protocol. Table 1 lists some standard protocols by taxon/habitat feature, and Table 2 offers some suggestions for collecting data based on the indicator(s) selected.

Say you've got yourself a measuring tape and GPS to measure tree diameters or a pair of binoculars for observing birds. Which areas should you survey and how much area should you cover? In most instances, it's not possible to survey the entire nature area or park, because it is too big or because some areas are not easily accessible. If you're using a standard protocol developed by an organization such as Audubon's Christmas Bird Count, the size of the observation area and survey duration have already been set; just follow the procedures as written and submit your data! If you have to design your own survey method, keep these two considerations in mind: (1) ensure that the survey area(s) adequately **represent** the habitat of interest, and (2) do only what is **practical** and **realistic** for your team's capabilities and resources.

Let's return to the tree-measurement example. Regarding adequate representation, if large trees (> 1 m diameter) have been selected as the target taxa as a proxy for old-growth forest status, you'd probably want to concentrate survey efforts on less disturbed areas with several large trees within close proximity, instead of highly disturbed areas near the edge of the park and main roads dominated by young trees and weedy vegetation. If there are three trails that go through the old-growth area, think about how much ground your survey team can realistically cover within the budgeted time (half a day, one day, etc.), and pick the trail with a good number of large trees (representation) while keeping things manageable for your team (being realistic). It is better to survey a short trail near the parking lot with 10 large trees then attempt to go for an extended trail over arduous terrain to reach 30 trees, because the probability of successfully returning to and surveying the first trail repeatedly is much higher. Regardless of the number of sample sites surveyed or area covered, it is important to repeat the same survey several times, as **consistency** leads to **comparability**. If you only manage to measure the same 10 trees every 5 years, that's great! You now have a long-term dataset with comparable data. Indeed, "a rough index obtained with an easily replicable method not highly dependent on the observer's individual skills may often outperform elaborate assessments"[4].

3.3.2 LOW-COST, LOW-EFFORT OPTIONS

Landscape visual change[5]

Perhaps your monitoring budget is close to $0 and your monitoring team is tiny. That's fine! It is still possible to monitor the habitat on a regular basis by simply visiting the site and recording observations on what has changed, visually, in the general land- or seascape. Make your assessment quantitative by scoring (1, Poor; 2, Fair; 3, Good; 4, Very Good) the overall condition of the habitat and record general comments (e.g., "The habitat condition is **Poor** this year with lots of dead seagrass patches. Perhaps the intense summer heat wave led to massive eelgrass die-off").

[5] Adapted from Islands Trust Conservancy's annual monitoring form for land covenants

[4] Werner FA, Gallo-Orsi U (2016) Biodiversity Monitoring for Natural Resource Management – An Introductory Manual. GIZ, Eschborn and Bonn, Germany. DOI: 10.13140/RG.2.1.3141.8488/1

It is useful to complement the assessment with photographs of the habitat taken at fixed points, such as at the beginning, middle, and end of the trail walked during each annual assessment. Similarly, videos provide a visual (and audio!) record of the habitat but have a greater storage need. Other information that would be helpful to note:

- Date and time of your visit
- Any major disturbances to the habitat and its inhabitants (e.g., wildfire, flooding, heat dome)?
- Any significant visual changes in the land- (e.g., tree clearing) or seascape (e.g., erosion of shoreline)?
- Any signs of pollution or contamination, including litter?
- Number of people encountered and their activities, especially if linked to a monitoring objective on visitor levels and impacts
- Number and types of wildlife encountered and whether they are rare, at risk, or otherwise of interest, which can be recorded on the iNaturalist app
- Any invasive species (plant and animal), which can be recorded on the Report Invasives or iNaturalist app.

Using satellite remote-sensing data

As with broadly assessing landscape visual change during a site visit, satellite images of a site can be examined to look for major changes in land use/land cover, structural changes (e.g., river shifting course, shoreline erosion), and impacts of disturbances (e.g., extent of flooding, wildfire). Images are captured repeatedly by satellites circling Earth, thus building up an image time-series for the site of interest. Free satellite imagery viewing platforms such as Google Earth Pro[6] and Zoom Earth include a historical archive of images that can be used to compare landscape-level changes over time, with no coding knowledge required. Search for your protected area using its site name or GPS coordinates. It is also possible to measure areas on both platforms, to track land use/land cover and forest cover, among other attributes (Fig. 2). The main drawback is that the "current" image of a site may be a few years old, as it takes a while for the platforms to update the images. Therefore, this approach is great for historical comparisons and comparisons over longer time scales (e.g., every 5-10 years) but is not suitable for frequent monitoring.

If you're willing to engage with a more complicated user interface or have some expertise in image analysis, more up-to-date imagery with additional features can be accessed from free online sources including Sentinel Hub's EO Browser, NASA Worldview[7], and USGS Earth Explorer.

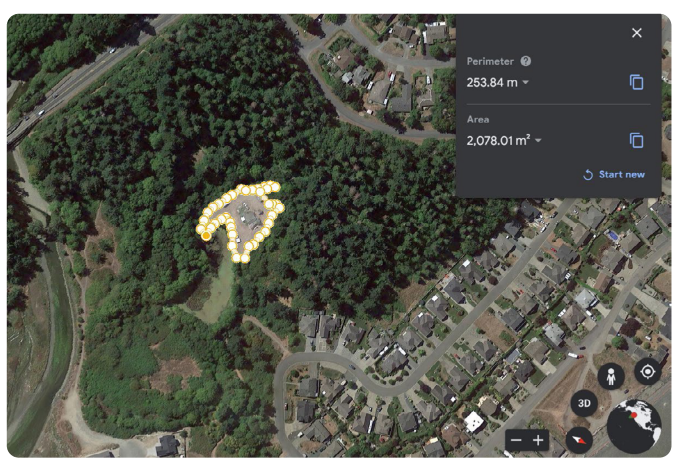


Fig. 2. A clearing in the French Creek Estuary Nature Preserve was outlined on Google Earth to calculate its area using the platform's measurement tool. This area can be repeatedly measured in subsequent years to track the rate of vegetation regrowth in the clearing. Image from 2019

[6] Get support at https://support.google.com/earth#topic=
[7] YouTube tutorial at https://youtu.be/uMkuiRJr_-E

Obtaining "free data" from other area users

If people are already using the nature area for recreation, hunting, and fishing, the step needed next is to collate their onsite observations to use as monitoring data. In fisheries, creel surveys (or angler surveys) are a well-established, widely used tool to gather information for recreational fishery management. A typical creel survey consists of interviews of anglers about their fishing outing. Information on the duration of the fishing activity and the number and types of fish caught can be used to estimate catch per unit effort (CPUE), an index of fish abundance, such as an average CPUE of 2.5 salmon per hour of fishing effort across all anglers interviewed. Similar interviews and questionnaires can be employed for commercial fishermen and hunters to obtain the CPUE or harvest per unit effort (HPUE) for target taxa. The CPUE or HPUE cannot be used to estimate the actual fish or elk population, but the assumption is that the larger the population, the easier it would be to catch or harvest more animals per hour of fishing or hunting. Ideally, increases or decreases in the CPUE/HPUE would reflect similar changes in the actual population. As mentioned previously, this type of monitoring should be coordinated with Fish and Wildlife staff who often conduct targeted surveys of these user groups. Do note also that for surveys and interviews, people are more likely to participate if they understand how the data would be used and if they have assurance that their privacy would be respected (e.g., don't release names and personal information online).

If there is a way for you to communicate with people visiting the nature area for recreation (e.g., sign at trailhead, social media), they may be persuaded to collect some information while they are enjoying the outdoors. This can include the presence and location of invasive plant species and encounters with wildlife. It's certainly useful to develop good relationships with local trip outfitters for this purpose as well. Provide a short list of questions you'd like answers to, and a way to submit the responses, whether by email or an online submission form. An example is this form developed by the BC Marine Trails Network for site condition reports by kayakers.

iNaturalist is a widely used, free, and powerful nature-reporting platform with a global reach. Users upload photos of observations or sound recordings and their locations, and iNaturalist's image recognition software suggests the identity of the organism. The observations can then be viewed publicly on the app or web platform. iNaturalist is great for obtaining a record of the species present in an area, especially with planned intensive surveys or bioblitzes, which are focused events recruiting a team of community scientists to record as many observations as possible in a specific location over a specified time period. In addition to species presence and location, it is possible to do some base-level monitoring with iNaturalist with outdoor recreationalists. For instance, if you have reason to suspect that an invasive plant species has been introduced to the nature area, you can install a sign at trailheads asking area users to report any sightings of the species on iNaturalist, so that the spread of this invasive species can be tracked and managed. It would be helpful to explain the need for such reports on the signs and include a QR code for downloading the iNaturalist app.

Excitingly (to us), iNaturalist can also be used for data upload and storage in monitoring projects involving surveys and measurements; see Box 1 for details.

For target species and habitat features that are of interest to other monitoring groups and government agencies, there are likely data on those species and features available in various online databases. Check out the hunting and harvest data accrued through the BC Government's Wildlife Information and Licensing Data system (WILD) , which collates reports from hunters and guide outfitters. Data for specific areas can be used to set up a baseline for future comparisons or monitored regularly to track HPUE and hunting activity. Other databases pertinent to BC include the Wildlife Tree Stewardship Atlas, which maps raptor nests and nest use, Pacific Salmon Explorer by the Pacific Salmon Foundation, and BC Water Tool, a map-based platform with data on streamflow and water levels.

3.3.3 TOOLS YOU CAN EMPLOY WITH MORE RESOURCES

Line/belt transects and plots

These are commonly used to measure density (number of individuals per unit area or volume) or percentage cover. One easy way to set a line or belt transect is to unroll a fiberglass measuring tape (30 m is a common length) across the habitat to be surveyed. In a line transect, the target organisms under the line are noted and counted, whereas in a belt transect, the target organisms within a fixed distance (e.g., 1 m) from either side of the line (i.e., a 2-m-wide belt) are counted (Fig. 3). These would produce density estimates per unit length (m) or area (m^2), respectively.

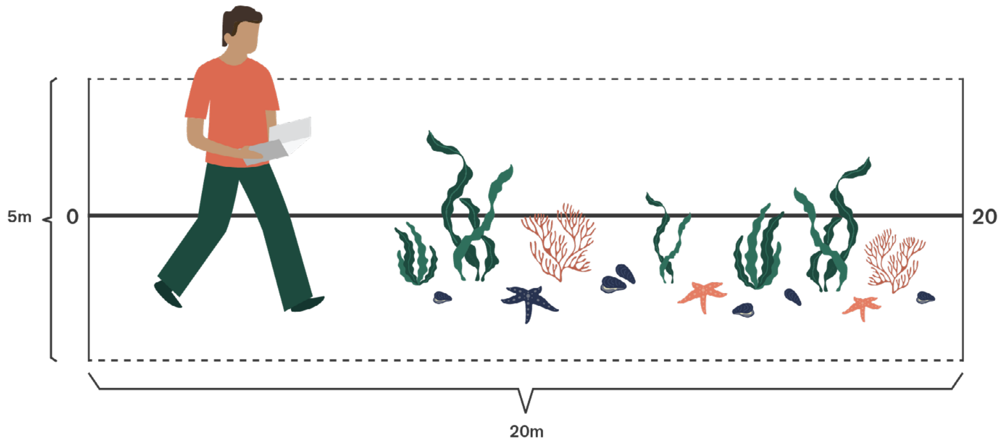


Fig 3. Example of a belt transect. A 20-m transect line is laid out, and monitors record information within 2.5 m of each side of the line for a 5 m x 20 m survey area.

Plots and quadrats are similar to transects in concept but have different shapes, tending to be square or circular rather than linear or rectangular. The number of individuals or cover of target taxa within each plot is counted or estimated. For a tree-growth survey, all the large trees within the plot are identified, mapped, and measured. A circular plot is established by fixing a central point and having a surveyor run a measuring tape from the center to a fixed distance (e.g., 10 m), which comprises the radius of the plot. The surveyor then walks at this fixed distance around the center to outline the circumference of the circle while other surveyors take note of what is within the bounds of the plot (Fig. 4a). Circular plots are used in forest monitoring but may be challenging for new monitors to deploy where many tall trees are present. Large square plots can be established by placing one surveyor at the first corner, and having two others run measuring tapes perpendicular to each other a fixed distance (e.g., 10 m). Repeat the rolling out of perpendicular lines from each new corner, and adjust the line angles until all sides of the plot measure 10 m (Fig. 4b). For even larger squares (e.g., 100 m x 100 m), it is also possible to determine the GPS coordinates of each corner on a map ahead of time and set up the plot onsite using the coordinates and a GPS unit.

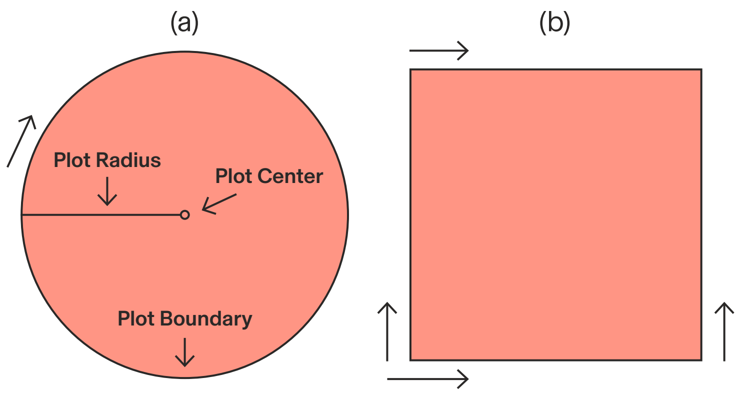


Fig. 4(a) Example of a circular plot. A line is extended from the plot center and traces the plot boundary around the circle. (b) Example of a square plot. Two perpendicular lines extend from the starting point at the bottom left, and additional perpendicular lines are rolled out from the next corners.

Quadrats are a “small” version of a square plot and usually measure 1 m x 1 m or smaller (Fig. 1). They can be made cheaply using PVC piping and corners from a home hardware store. Use quadrats in tandem with a line transect by placing them on either side of the line at fixed interval or establish fixed placement points using GPS coordinates or markers. Quadrats are useful in biodiverse areas such as an intertidal habitat where a 10 m x 10 m plot could take several hours to survey thoroughly.

Compared to methods such as remote sensing and monitoring visual change, transects and plots provide sought-after density and cover data using cheap materials but are time- and labor-intensive. Decide on the distance and area as well as the number of replicate transects and plots to survey based on what is reasonable given volunteer capabilities and the time available. One 30-m transect or 10 m x 10 m forest plot is fine, if that’s all that’s possible to survey well during each monitoring visit.

Associated costs: fiberglass measuring tape – ~$30 for a 30-m tape, PVC piping and elbows – ~$1.50/m and $1/each from home hardware stores

*Note: fiberglass tape can be used to measure tree circumference for calculating tree diameter or, free measurement apps (Google Measure for Android, Measure for iPhone) are available on recent smartphones.

Water quality monitoring kits

Kits make it easy to measure water quality parameters such as nutrient, oxygen, coliform, and turbidity levels in water bodies in aquatic habitats. All the reagents, sampling bottles, and test tubes required are included together with an instruction manual in a portable, easy-to-carry package, and the tests are simpler to carry out than with expensive water quality dataloggers. Water Rangers has an online shop carrying water quality test kits of various sizes, from $24.50 for a Tinykit to $360 for a more comprehensive Explorer Testkit. Do note that because water quality parameters can change rapidly, such as the dilution of nutrients after heavy rainfall, water quality readings should be taken at least monthly.

Remote cameras

Remote cameras (also known as wildlife cameras, camera traps, and trail cams) are getting affordable enough to be increasingly deployed by backyard biodiversity enthusiasts curious to find out who the other animal inhabitants of their neighborhoods are. These cameras are great for capturing photos or videos of animals that tend to avoid people or nocturnal animals, including many species of mammals, that would otherwise be missed in in-person surveys. The camera has a motion sensor that triggers a shutter release when an animal passes in front of it, whereupon a series of photos or a short video is recorded. Once cameras have been deployed in the field, they can be left unattended for up to 1 year before changing batteries and retrieving memory cards.

Similar to iNaturalist, remote cameras provide information on what animal species are present in the area and can be very useful for verifying the presence of rare species. In addition to species presence, camera images can be examined to determine the reproductive period of target species (based on when young are spotted), assess animal body condition (e.g., whether animals look well-fed or starved), and track the status of identifiable individuals with distinct markings. Unlike iNaturalist, there is a steeper learning curve for using cameras, especially in managing potentially large amounts of photos and videos. Do go through this guide to camera trap set up and other protocols developed by WildCAM, if this method is one you’re interested in.

Associated costs: Remote cameras range from $200 to $600 each and can be purchased online directly from camera manufacturers or from outdoor sports shops (e.g., Cabela’s). See this WildCAM resource on choosing a camera model. You also need AA batteries (usually 8-12 per camera; prices vary) and memory cards (one per camera; ~$20 for a 64 GB SD card). Other accessories to consider are cable locks (~$25 each) for securing the cameras and protective camera cases (starting from $35 each) if the wildlife—or people—in your area have a tendency to tamper with the cameras.

eDNA kits

Environmental DNA (eDNA) analysis is yet another way of collecting species presence information. As animals move through the landscape, they shed bits of their genetic material, their DNA, into the environment. Through laboratory analysis of water or soil samples containing this genetic material, DNA fragments can be matched against a global database of sequences to identify the taxa the DNA belongs to, thus providing a species presence list for the nature area. As you can imagine, it is possible to find species not observed during in-person surveys or by remote cameras (e.g., small mammals, amphibians, birds, fish) using this method. This field is growing rapidly, with the IUCN and NatureMetrics establishing a "global atlas of life" based on eDNA called eBioAtlas. Easy-to-use sampling kits for water and soil are available from NatureMetrics and other companies for ~$600 each, including lab analysis. The cost may appear steep upfront, but it is usually quicker to sample water at a few points to represent the entire area (e.g., in 1 day) than conduct intensive on-the-ground surveys to try and observe the same species, which could take a few weeks to months. Rather than only choosing one of the survey methods presented, think of eDNA analysis as a good complement to *in situ* (on-site) surveys (vegetation, slowmoving animals) and camera trapping (medium-sized to large mammals).

In terms of monitoring with eDNA, species richness can be tracked over time, as well as the presence of taxa of interest and species composition (the identity and abundance of species present in a certain area), e.g., how many predator species vs. prey species, which can be used to assess food chain integrity among other aspects of ecosystem functioning.

Consumer drones

Small drones carrying a camera can be very useful for covering broad areas in habitat surveys. They can capture video footage along predefined tracks to monitor visual change in the landscape or recovery after a major disturbance. Overhead photos of the landscape can be analyzed as with satellite images to tracks changes in land use/land cover or vegetation. Drones can even be deployed over coastal habitats with clear water, particularly when the tide level is lower, to observe seagrass beds, kelp forests, oyster reefs, and herring spawning aggregations. Basically, anything that would be useful to observe from an overhead view. Note that the drone has to weigh less than 250 g to not require a drone operator licence in BC and that drone operation is restricted in many areas such as provincial parks and controlled airspace. A park use permit or other authorization is required to fly a drone in a park. Do your due diligence and check the regulations in place before use.

Associated costs: Mid-range drones are available from several online shops and camera vendors for $500-700. You may also need to purchase a memory card (~$25 for a 128 GB microSD card).

Other useful items

GPS unit – provides more accurate coordinates than a cellphone, and can mark waypoints and save tracks that can be retraced in subsequent surveys. Starts at ~$150 for a basic Garmin model. Alternatively, Bluetooth GPS receivers can be paired with your smartphone or tablet to boost the accuracy and precision of position information on your device ($130 for a Garmin GLO 2), especially if you use free mapping apps such as Gaia GPS.

Binoculars – particularly useful for bird surveys. They can be found at several price points (starting at ~$60), depending on the lens quality and magnification power, from outdoor retailers, manufacturers, and online stores.

Camera with zoom lens – similar to binoculars but with image capture. Good for surveys in which images of birds and other small animals are needed. Prices vary depending on the manufacturer and zoom distance; budget ~$1500-2000 for a mid-range camera and lens package. If you don't need a zoom lens, many smartphones come equipped with fantastic cameras.

Waterproof notebooks and pencils – for data recording in the field regardless of the weather. For consistent data recording, it's a good idea to provide each surveyor with a datasheet template for their notebook. Depending on the notebook size, prices for Rite in the Rain products range from ~$5.50-30. A paperless option would be to use an app, online form, or voice recorder to collect data, but mobile devices are more challenging to waterproof!

Identification (ID) guides – for surveyors to learn about and confirm species identifications. This could take the form of guidebooks (prices vary, secondhand versions are cheaper) or you could make your own guidesheets with photos and descriptions and laminate those (~$2-3/page). For a paperless option, convert the guidesheet into a PDF to share with your volunteers.

Online storage – especially if you anticipate collecting hefty amounts of photos and videos (e.g., camera-trapping projects). Consider using an online drive that can be shared among survey team members, so data storage does not depend on a single person, and multiple persons can upload data. Many providers offer free accounts with limited storage to start with, and you can pay a subscription fee if you need additional storage. If you have a Google account, you already have Google Drive, and Sync is an option for cloud services located in Canada. If you are using a community science platform such as CitSci.org or partnering with a parks agency, data storage is usually included as part of the package.

Safety gear – Most data collection activities would take place in the outdoors; thus, it is important to check the conditions for the time you and your team would be outside, create a trip safety plan and carry appropriate safety gear, such as the 10 essentials.

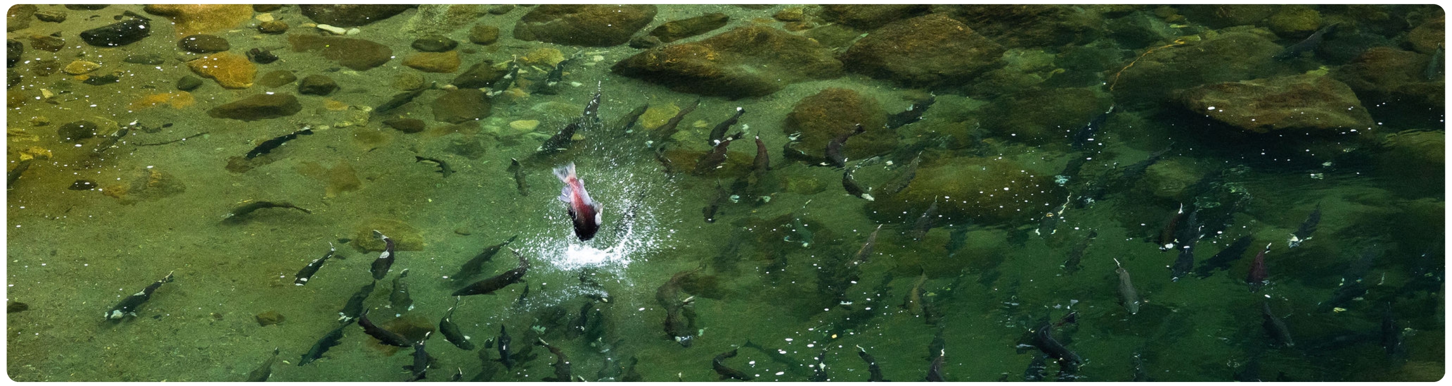
Outreach

A reminder here that checking in and authorization from the protected area manager (e.g., BC Parks, regional parks department, landowner, etc.) is required before enlisting volunteers for a monitoring project. Now that's done, projects that rely on members of the public to sign up as volunteers require significant outreach, so that the general public or local community members are aware of the project and why they may be interested in participating. If you already have a large audience on social media or your email list, this may be as simple as posting an update. If you need help with building your audience, do reach out to us! Other outreach approaches include putting up posters on community bulletin boards, giving talks at public libraries and in schools, and installing signage (in collaboration with the local protected area authority) at trailheads.

3.3.4 WHEN AND HOW OFTEN TO MONITOR

We've talked about what to monitor (indicators) and how much area to cover, but what about when to monitor? Given that we live in a seasonal climate, surveys should be planned during the time you are able to observe the organism, behavior, or feature of interest. Obvious examples include eagle nesting season (spring) to monitor nest productivity (i.e., whether there are eaglets in the nest) and salmon spawning season (fall) to count the number of returning salmon in a stream. Terrain accessibility is another consideration. It is possible to identify and measure the diameter of coniferous trees in winter, but a thick snowpack would make it difficult, and unsafe, to move through the landscape.

As for the frequency of monitoring, whether surveys should be carried out weekly, monthly, yearly, or at other intervals generally depends on the rate of change expected with your indicator. We mentioned earlier that water quality parameters change rapidly, even hour to hour, and at minimum, should be monitored monthly. By contrast, large trees grow slowly, so slowly that you may not see any difference in diameter from year to year, and so, measurement of the same trees every 5-10 years may be sufficient. Some salmon such as pink and sockeye have dominant year cycles. These should be noted and included in any salmon monitoring plan. Annual monitoring is fine in most cases—for abundance vegetation cover, and landscape visual change—and should be carried out at the same time each year.



3.3.5 WORK OUT THE MONITORING BUDGET

Based on the indicators selected and the costs of the survey methods and gear used (as discussed above), work out the budget for **field gear**. Scale up the cost accordingly depending on the number of survey team members and the area to be covered. Note that some gear are one-time purchases that can be reused in subsequent surveys (e.g., camera, binoculars), whereas others have to be replaced on a regular basis (e.g., batteries, notebooks). A mandatory piece of field equipment is a well-stocked first aid kit, and a qualified first aid provider should ideally be present in the team, i.e., budget for first aid certification or recertification if necessary.

Another major cost is **transportation**, particularly for remote areas without transit options. Budget for vehicle stipends that cover mileage or the cost of gas, or bus rental to transport a larger group. Transportation via water taxi and chartered flights is highly expensive; you would need a substantial, steady funding supply to conduct monitoring in extremely remote areas.

A budget component that may be overlooked is what we like to call "**volunteer care**." Volunteers commit time and energy, often without pay or at their own expense, to ensure the success of your monitoring project. Small gestures of appreciation go a long way in maintaining morale and volunteer retention. This could take the form of covering vehicle mileage (see blurb on transportation above), printing T-shirts or ballcaps for volunteers to wear in the field, or providing food and beverages for volunteers after a tiring survey day. It's often nice to organize an annual gathering of the volunteers with refreshments to celebrate and share results, stories, and experiences gained over the season.

3.3.6 HERE'S YOUR SURVEY PROTOCOL!

To keep track of all the components comprising your survey protocol and ensure you're not missing anything, fill in our Project Builder form (Appendix 1) as you run through the process of selecting objectives, developing research questions, determining the target habitat features and taxa followed by indicators, designing the measurement and data collection methods, and working out the budget (see Box 2 for a case study). You should now have a written survey protocol that you and your survey team can refer to. Next up is data management (including analysis) and reporting. But first, some quality assurance/quality control (QA/QC) considerations:

- Check that the indicators selected and data to be collected address the monitoring objectives and are aligned with the needs of the protected area manager/park authority. Can you answer the research questions using the monitoring results?
- Does the survey method follow one from an established monitoring program such as salmon counting by the Streamkeepers (see Table 1 for more protocols)? If not, we encourage you to send in your protocol for review (details below)
- Is the survey coverage reasonable or overly ambitious? For example, the likelihood of successfully finding and measuring 100 large trees along a 20-km route in one day with two people is very low. Instead, aim for 10-20 trees over 5 km, and perhaps only survey the most common large tree species
- Once your survey method is established, design a datasheet template for the volunteers to use and plan some volunteer training. For simple surveys, handouts could be distributed to the volunteers; for more involved surveys, you might want to schedule in-person or online training sessions. Surveyors should attend a refresher if there is a long gap between successive surveys.

Send your monitoring plan for review!

You're invited to reach out to the Community Science team at the BC Parks Foundation for consultation on your monitoring project in BC and review of your monitoring plan (please include your completed Project Builder form). Consider us your friendly provincial community-based monitoring resource!
Contact us at communityscience@bcpf.ca.

4. Data management – what happens after data are collected

It takes a lot of hard work and investment to gather field monitoring data. It is thus critically important to find a "home" for these data, so that they can be usefully applied for ensuring that implementation of the protected area status is working, annual reporting to donors and supporters, checking the outcomes of management interventions, and so on. The regular publication of data summary reports with resulting management outcomes is another form of communication that helps motivate and encourage volunteer participants to continue with their efforts. As part of your planning process, determine who would be in charge of data management, including collecting and storing datasheets or logbooks as well as entering data.

4.1 DATA UPLOAD AND STORAGE

There are a few options here, depending on what you and your team are familiar with and comfortable using. Ideally, you'd want to have data in an electronic format such as a worksheet (Excel or Google Sheet) for comparisons and creating graphs. In a worksheet, it is recommended to have each row represent one data record (see Fig. 5)—this makes it easy to sort the data and use the filter function to find particular data records. If data were transcribed off hardcopy datasheets, photograph each datasheet as a backup and file these photos by sampling season. It's a good precautionary measure to have data stored in different formats and places, i.e., to have redundancy. Check the dataset soon after data entry to correct any mistakes or omissions that might have occurred during the entry process.

Label photos relevant to each data record (e.g., overhead view of a quadrat) accordingly (e.g., 2022PorteauCove_LowtideQuadrat5). Cloud storage or an online drive serves as storage backup for data worksheets and photos and makes it convenient for different team members to share resources and access materials, versus someone's personal hard drive on a computer. Free online storage ranging from 2 GB to 15 GB is available from Sync, Google Drive, Dropbox, and many other providers. Additional storage can be purchased if necessary.

Tree ID	Date	Scientific name	Common name	CBH (cm)	Latitude	Longitude
135819778	2022-09-10	Thuja plicata	western redcedar	535	49.49284	-123.34053
135838840	2022-09-10	Acer macrophyllum	bigleaf maple	482	49.49297	-123.34049
135838841	2022-09-10	Acer macrophyllum	bigleaf maple	555	49.48779	-123.33823
135838842	2022-09-10	Pseudotsuga menziesii	common Douglas-fir	472	49.47608	-123.33564
135843223	2022-09-10	Pseudotsuga menziesii	common Douglas-fir	467	49.47519	-123.33634
135843224	2022-09-10	Pseudotsuga menziesii	common Douglas-fir	391	49.47309	-123.33823
135843225	2022-09-10	Pseudotsuga menziesii	common Douglas-fir	385	49.46321	-123.34514
135843226	2022-09-10	Pseudotsuga menziesii	common Douglas-fir	440	49.46	-123.34702
135843227	2022-09-10	Pseudotsuga menziesii	common Douglas-fir	420	49.45508	-123.34966
135843229	2022-09-10	Pseudotsuga menziesii	common Douglas-fir	454	49.45452	-123.34595
137210641	2022-10-01	Pseudotsuga menziesii	common Douglas-fir	394	49.44197	-123.34265
141200241	2022-04-15	Pseudotsuga menziesii	common Douglas-fir	550	49.48133	-123.42489
141200242	2022-04-15	Pseudotsuga menziesii	common Douglas-fir	503	49.48113	-123.42521

Fig. 5. Example of a worksheet containing circumference at breast height (CBH) measurements of large trees on Gambier Island. Each row in this worksheet represents an individual tree measured in 2022.

For simple biodiversity monitoring projects, we highly recommend using iNaturalist as the data upload and storage platform. In addition to uploading photos, date/time information, and location information for each observation, data such as tree circumference measurements, general weather and habitat observations, organism condition, density, and vegetative cover can be included as Observation Fields. These fields can even be required as part of a Traditional Project in iNaturalist (see Box 1). Nicely, photos are automatically linked to the data for each observation record in iNaturalist instead of stored in a separate folder. Data from the project can be extracted and downloaded as a worksheet when you're ready for analysis.

For more complex monitoring projects with multiple indicators and non-taxon-associated indicators (e.g., water quality parameters, landscape features), CitSci.org may be a useful host platform. Similar to iNaturalist, it is an all-in-one platform where you can store monitoring data and photos under a single project. Create a project on CitSci to manage participants, make customized datasheets, upload and store data, and conduct simple analysis. More than 1000 community science projects are currently hosted on the platform.

4.2 DATA INTERPRETATION

After wrapping up data collection for the season, it's time to work on simple data summaries and work out what the data are saying (i.e., data interpretation). If there are previous data from earlier sampling seasons, you can compare data across time and look for trends.

For numerical data, a simple summary is to calculate the average, such as the average density of mussels across 10 quadrats sampled on a rocky beach. If more than three samples were taken, the minimum to maximum value range can be noted or standard deviation calculated, to get an idea of how widely the measurements vary. For organism size measurements, if the size range is enormous and there are several very small and very large individuals at each site, such as with trees, it might make more sense to track tree growth (change in size over time) than the average tree size for a particular area. In this case, you would assign each tree a unique identifier code (e.g., ForestX_Dougfir01) and subtract the previous year's tree circumference measurement from the current year's to calculate tree growth, i.e.,

Growth of ForestX_Dougfir01 from 2021 to 2022 = Circumference of ForestX_Dougfir01 in 2022 –Circumference of ForestX_Dougfir01 in 2021.

Average tree growth for each species can then be calculated and tracked as the metric of interest.

Once you have collected data over a few seasons, you can plot line or column charts to see average values on a year-to-year basis at a glance (Fig. 6). Put the year on the x-axis (horizontal axis) and the indicator you're measuring on the y-axis (vertical axis). If you have data ranges or standard deviations, plot those on the chart too.

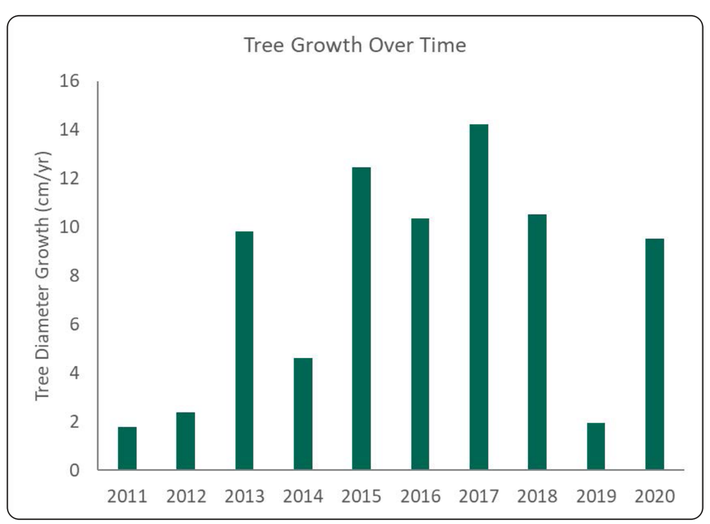


Fig. 6. In this example graph of tree growth over time, diameter measurements of large trees from a single species were taken each year from 2011 to 2020, and the average change in tree diameter from the previous year (i.e., growth per year) was calculated for each year. Although tree growth fluctuated year-to-year, there was an overall trend of increased growth from 2011 to 2015, and tree growth remained relatively stable until 2019, when there was a sharp decrease, before recovering again. Thus, conditions were likely suitable for tree growth from 2015 to 2018, but there was a major event that greatly depressed growth (e.g., severe drought) between 2018 and 2019.

Some research questions that can be answered by simple comparisons or trends monitoring are:

- Are there major changes in the abundance/density of species X over time?
- Has the vegetation cover increased after the wildfire in year Y? How long does it take for the vegetation cover to reach its pre-fire level?
- Did drought in year Z negatively affect the growth of Douglas-fir trees in the following 5 years?

Looking at Figure 6, tree growth doesn't stay the same from year to year. This is expected as there's a lot of variability in nature—the amount of sunlight, rainfall, nutrients and many other inputs that affect tree growth change daily in myriad ways. What we are interested in are big changes that point to major disturbances or heightened stress levels, such as a >50% decrease in tree growth in a year with severe drought or a disease outbreak. For projects that involve recovery or restoration, we want to know if, on average, the population or vegetation cover has been increasing since the population or habitat was protected or restored (Fig. 7). In CitSci, charts can be easily generated from your dataset as part of the data analysis function.

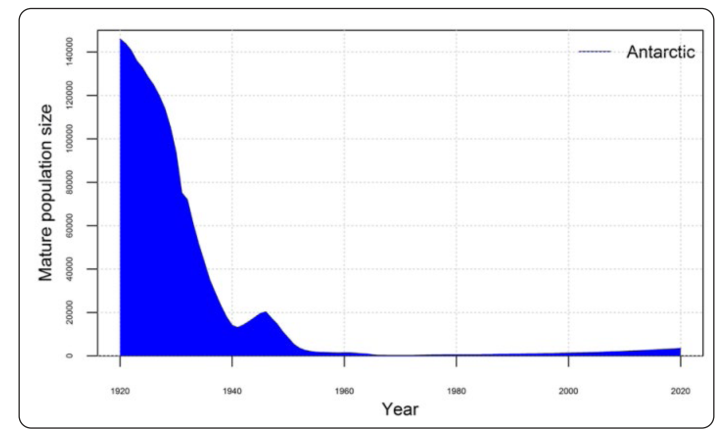


Fig. 7. The blue whale population plummeted after commercial whaling began in the late 1800s, and the species is currently considered endangered. Whaling all but ceased during the 1960s–70s due to extremely low whale numbers, and a moratorium on all commercial whaling was enacted by the International Whaling Commission in 1985. Since then, there has been a slow recovery, as seen by the data on Antarctic blue whales above, with the population considered to be increasing. However, the current population size is not anywhere near pre-whaling levels, indicating that protection efforts need to continue. Graph from the IUCN Red List, additional information from the IUCN Red List blue whale page.

With high natural variability, oftentimes trends and significant changes are only obvious with a long-enough time series obtained from long-term monitoring; thus, it is important to establish clear and simple research questions and continue monitoring in a consistent manner.

5. Using monitoring data to inform decision making

5.1 REPORTING RESULTS

An important but sometimes overlooked component of monitoring is results communication. We recommend publishing regular reports (at the end of every survey season, usually annually) with at least a data summary, a simple chart, and a few lines explaining what the data mean (e.g., tree growth has declined tremendously this year, likely because of the severe drought last summer). Make sure to send reports to all volunteer monitors, the protected area manager, and any donors or supporters of the project. Reports don't have to be formal; they can be posted on social media, the project website or blog, or in a mass email, whichever communication channels reach your audience. These reports not only provide useful information for the protected area manager but also help keep the public and volunteers engaged and informed, thus inspiring the public to support monitoring efforts and motivating volunteers to continue with the program.

5.2 LINK TO DECISION MAKING/MANAGEMENT

It is easy to get lost in the fine details of sampling in the field and all the numbers recorded and calculated as part of data collection and processing. Throughout the monitoring process, it is essential to pause now and then to think about the research questions driving the monitoring program, the decision makers and managers who would use the results, and the responses to activate based on the results. In Section 1, we highlighted some scenarios showing how monitoring results can inform management decision-making. Let's recap using the cover of an indicator species—eelgrass—as an example.

Result	Response
Meeting target – no changes (Fig. 8a) Eelgrass cover remains high (70-100%), no major changes noted	*Business as usual*, no additional actions needed
Meeting target – increase in cover (Fig. 8b) Eelgrass cover increasing from low level after restoration effort	*Business as usual* OR *Expand* restoration program to other eelgrass areas
Slight decline in cover (Fig. 8c) Eelgrass cover decreases to 50% from previous steady levels of 70-80%	*Caution*, take note and continue monitoring. Take action if there is further decline, business as usual if the eelgrass cover increases again. You may want to monitor more frequently and try to identify possible causes of the decline.
Steep decline in cover (Fig. 8d) Eelgrass cover decreases to <10% in a few years from a previous slight decline from 80%	*Take immediate action* to mitigate, ideally starting from 2016, when the first sharp decline is noted. If causes of the decline are known, remove or lessen the impact and reduce stress to the eelgrass, e.g., close off area to visitors or fishing, and continue monitoring. If conditions are suitable, restoration may be considered.

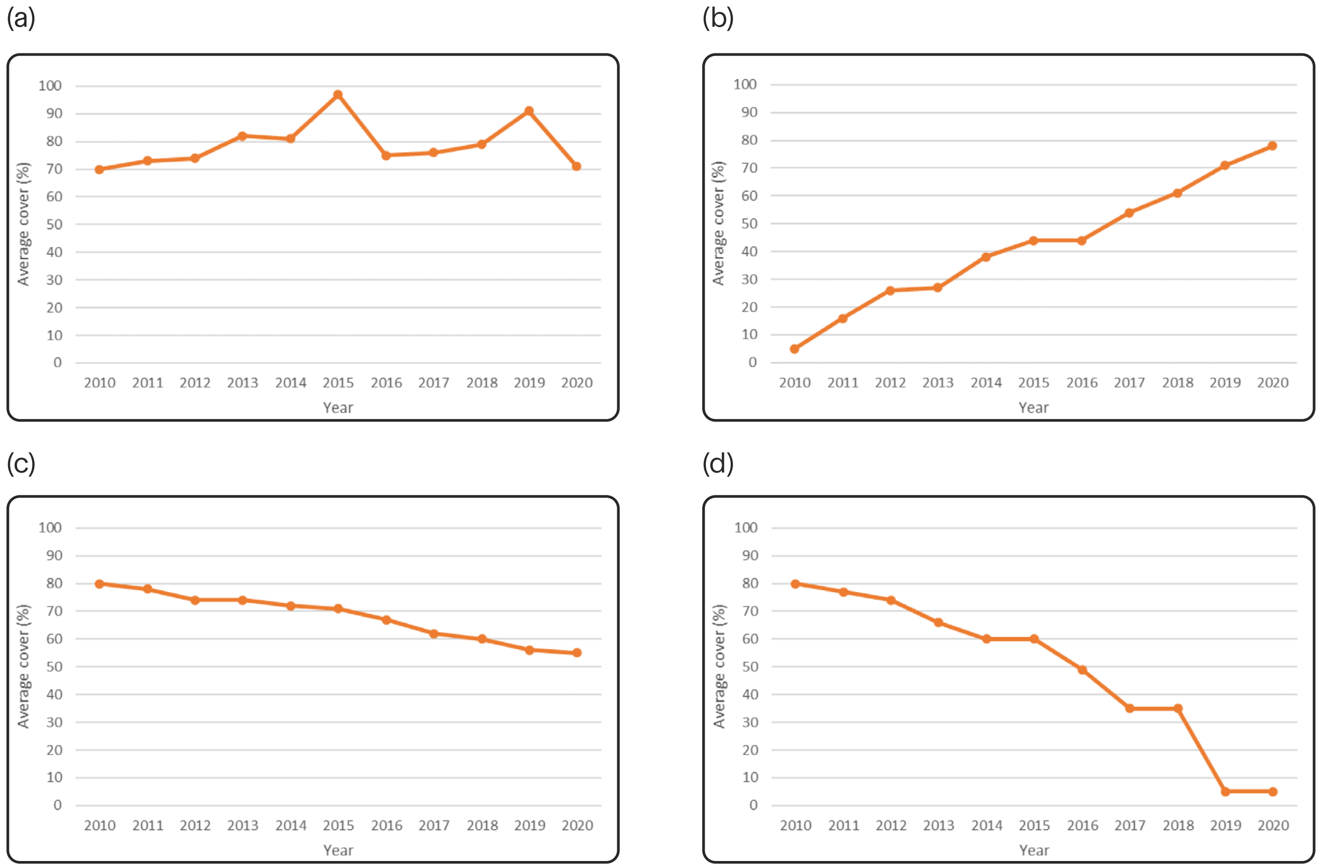


Fig. 8. Four scenarios of eelgrass percentage cover over time: (a) remaining stable, (b) increasing from a low level, (c) decreasing slightly, and (d) decreasing sharply.

Closing words

We hope that these guidelines provide enough background information and give you the confidence to go and start your own monitoring program for your local nature area. Remember that it's much better to first start with a simple plan with one indicator than spend too much time perfecting a complicated data collection strategy. Aim for a project that is easy to implement, cost-efficient, and sustainable. Finally, we're here to help! This is a living resource that will be updated with new information—do check back frequently. Contact us at communityscience@bcpf.ca for questions related to establishing a community-based monitoring program, including plan review. Engaging in community science is one of the most rewarding ways of participating in nature area stewardship, and a great way to meet like-minded community conservationists. Thank you for your efforts in protecting and stewarding these lands and waters!

CBM Toolkit – Table and Boxes

TABLE 1. List of standard monitoring protocols by habitat and target taxa or feature

Habitat	Target taxa/feature	Link to protocol
Various	Birds	eBird: Completing an eBird checklist Audubon: Christmas Bird Count
	Eagle, osprey, and great blue heron nests	Wildlife Tree Stewardship Program: instructions; nest monitoring app
	Butterflies	eButterfly: Checklist methodology
Forest	Big trees	BC BigTree Registry: How to measure tree circumference (pg 7)
	Soapberry	BC Parks Long-term Ecological Monitoring (LTEM): Soapberry production counts
	Squirrels	BC Parks LTEM: Red or Douglas squirrel abundance survey
Grassland	Plant community	BC Parks LTEM: Grassland plant community structure protocol
River/Stream	Stream features	Streamkeepers: Introductory or advanced stream habitat survey
	Water quality	Streamkeepers: Water quality survey
	Fish, salmon	Streamkeepers: Juvenile fish and spawning salmonid surveys
	Fish catch per unit effort	Streamkeepers: Creel survey for sport fishing effort
	Invertebrates	Streamkeepers: Stream invertebrate survey
Lake	Water quality	BC Lake Stewardship and Monitoring Program: Level 1-3 Studies. Lakekeeper's manual for lake stewardship and ecology
Wetland	Amphibians	BC Parks LTEM: Amphibian protocol
	Waterfowl	BC Parks LTEM: Waterfowl protocol
	Amphibians & Birds	Marsh Monitoring Program by Birds Canada
Alpine	Plant community	BC Parks LTEM: Alpine community structure protocol
Seagrass	Seagrass species	Seagrass Watch: Free training program for monitoring
Marine intertidal, e.g., rocky shore	General biodiversity	MARINe Biodiversity Surveys or Long-term Monitoring surveys

TABLE 1. List of standard monitoring protocols by habitat and target taxa or feature

Target taxon	Indicator	Protocol	Gear/tools needed
Birds	Bird count	Follow the eBird checklist or Audubon Christmas Bird Count protocol. Conduct counts at regular intervals (monthly, annually)	Binoculars, bird ID guide, notebook or datasheet, eBird app
Mammals	Species presence	Set up remote cameras in area. Identify mammal species and location from camera photos	Remote cameras and accessories, batteries, storage cards, computer eDNA sample collection kits
	Species presence	Collect and filter water samples from streams. Send filter samples to lab for eDNA analysis	
	Species harvest per unit effort	Distribute logbooks to hunters for daily records or interview hunters during hunting season	Waterproof logbooks
Fish	Fish abundance/catch per unit effort	Streamkeepers creel survey; Distribute logbooks to fishermen for daily records or interview fishermen during fishing season	Waterproof logbooks
	Spawning salmon abundance	Count spawning fish along streams during spawning season, following the Streamkeepers protocol	Notebook or datasheets, salmon ID guide
	Species presence	Collect and filter water samples from streams. Send filter samples to lab for eDNA analysis	eDNA sample collection kits
Trees	Tree cover	Calculate from aerial photos or satellite images	Image analysis software
	Large tree size and location	Measure circumference of trees >1 m in diameter at breast height. Note tree species and take a photo of the tree. Record GPS coordinates of each large tree measured	Measuring tape, datasheet or iNaturalist app, tree ID guide, camera, GPS
Sessile organisms (marine invertebrates, plants	Taxon density or cover	Count number of individuals or estimate percentage cover along line or belt transects or in quadrats/plots	Transect tapes, quadrats, datasheets, ID guides, camera, GPS

Target feature	Indicator	Protocol	Gear/tools needed
Water quality	Salinity, fecal coliform, dissolved oxygen, temperature, pH, turbidity, nitrate, phosphate, chlorophyll	Sample water at each station at regular intervals (e.g., monthly). Follow individual protocol for each parameter according to monitoring kit's instructions.	Water quality monitoring kit, sampling bottles, datasheet
River/creek hydrometry	Water level	Install a physical or virtual staff gauge and read off levels at regular intervals	Datasheet or CrowdWater app for the virtual gauge
Intermittent streamflow	Timing and presence of wet/dry streams	Record date, photo, and location of wet/dry streams as and when encountered using the CrowdWater app	CrowdWater app
Land use/land cover	Land use/land cover areas and percentages	Calculate from aerial photos or satellite images	Image analysis software

Box 1. iNaturalist as a tool for biodiversity monitoring

Introduction to iNaturalist

iNaturalist is a powerful, trusted community science platform used around the world to crowdsource observations of plants, animals, fungi, and other organisms. Users upload photos or sound recordings via the iNaturalist mobile app or website, and iNaturalist's image recognition software suggests the identity of the organism. A community of keen amateur naturalists called "identifiers" then confirm the identity of documented species, helping correct any errors and verify observations, so you don't need to be a species expert to join in the fun. There are now more than 2.5 million iNaturalist observations for BC!

These data help with documenting the biodiversity of BC's wild areas, such as determining records of rare and threatened species and mapping the spread of invasive species. In a province as vast and habitat-diverse as BC, data reporting by community scientists is critical for filling knowledge gaps for biodiversity conservation and management, especially in more remote provincial parks. For example, dated records of spawning salmon help with tracking changes in spawning time by species and location, and geo-tagged photographs of black bears grazing (do be Bear Aware!) tell us more about bear emergence times and where their important feeding grounds are.

Here's how to get started with iNaturalist:

1. Download the iNaturalist mobile app from Google Play or the App Store, or go to www.inaturalist.ca. Register for a free account
2. Turn on location services or the GPS function on your smartphone or camera, or take note of your location
3. On your smartphone, open the iNaturalist app, hit the "Observe" button, and start recording observations! If you're using your camera instead, you'd have to wait until you access your computer to upload observations. Take photos of wild organisms including plants, animals, and fungi or other signs of life such as feathers, nests, or tracks. Take sound recordings of birds and amphibians.
4. When you have internet access, upload your observations through the app or the iNaturalist website. Fill in details of the observation yourself or choose from iNaturalist's suggestions. Don't know what you're looking at? iNaturalist will offer a suggested identification. Otherwise, choose a broader group such as "mosses" or "butterflies." This helps the iNaturalist community find your observations.

Your uploaded and submitted observations are automatically shared with the iNaturalist community. Other community scientists can then comment on your observations, confirm what you saw, and provide identification suggestions.

Adding Observation Fields to your iNaturalist observations for monitoring

Besides reporting interesting nature sightings, iNaturalist can be used for easy data upload and storage in simple monitoring projects involving surveys and measurements. Here's how:

In iNaturalist, "Projects" are created to collate nature observations for specific events or locations. Many of these are Collection Projects, which aggregate observations that meet the criteria for inclusion in the project (e.g., particular species, location, etc.). Two or more Collection or Traditional Projects can then be grouped under an Umbrella Project. Learn more about iNaturalist Projects here.

The minimum information required for an iNaturalist observation is a photo or sound recording, a broad species identification (even "Plants"), the date of observation, and the location. With a Traditional Project, you can require one or more Observation Fields to record additional data including measurements, such that each observation is now associated with a date and measurement. If this is repeated annually, you now have a time series of measurements associated with individual organisms in a location. As an example, the BC Parks Foundation created a Traditional Project on iNaturalist called

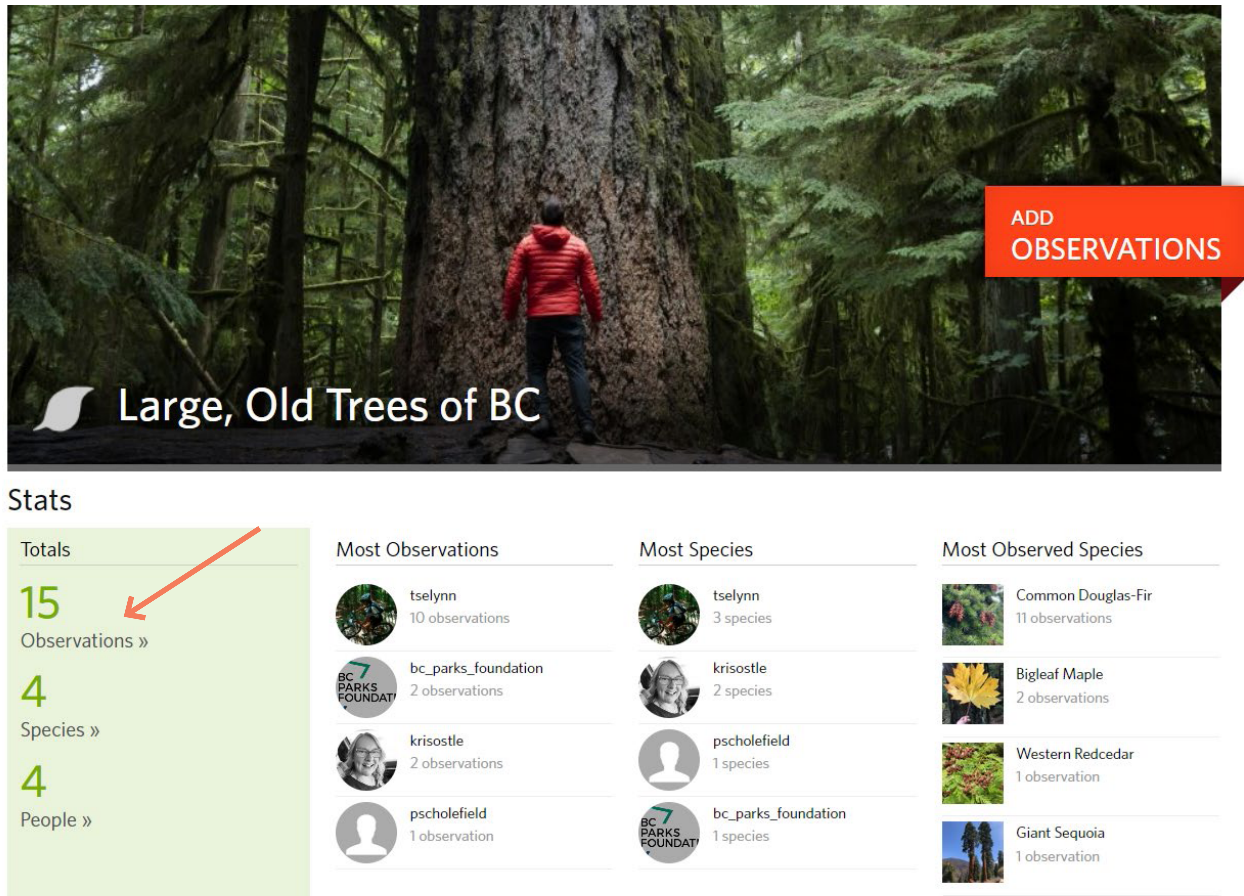
"Large, Old Trees of BC" for monitoring the growth of large trees. Monitors are required to add a circumference at breast height (CBH) measurement with each tree observation for their observation to be included in the project. Note that you need to have at least 50 verifiable observations on iNaturalist before you can create a Traditional Project.

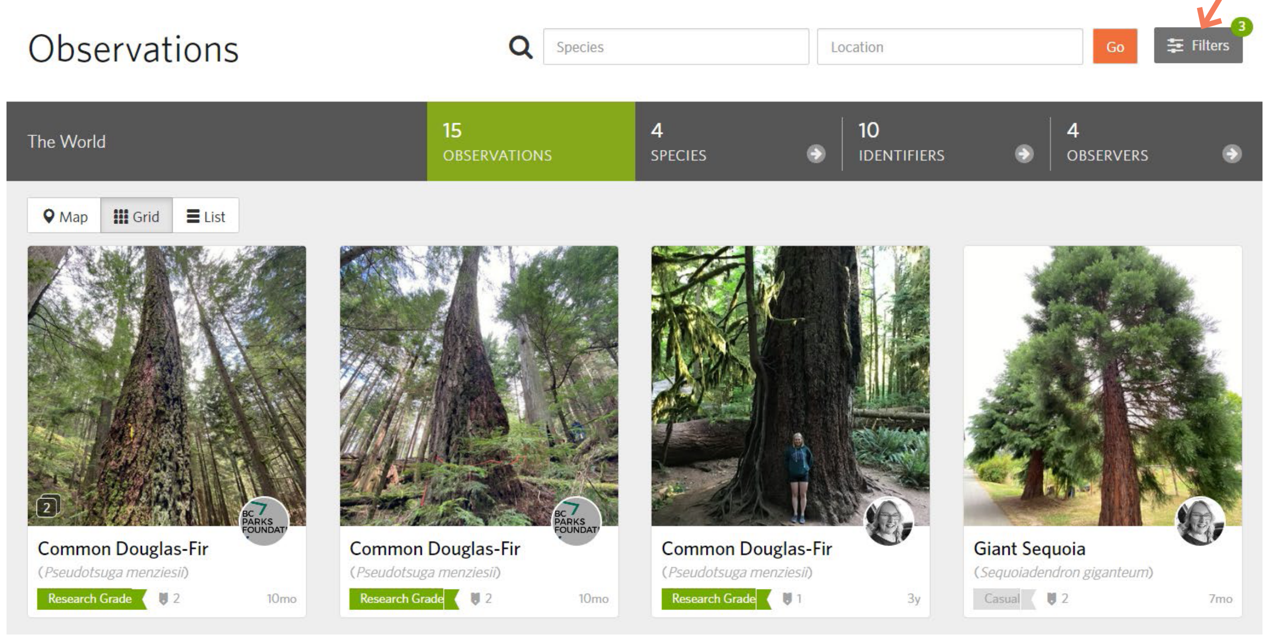
To set up a Traditional Project for monitoring:

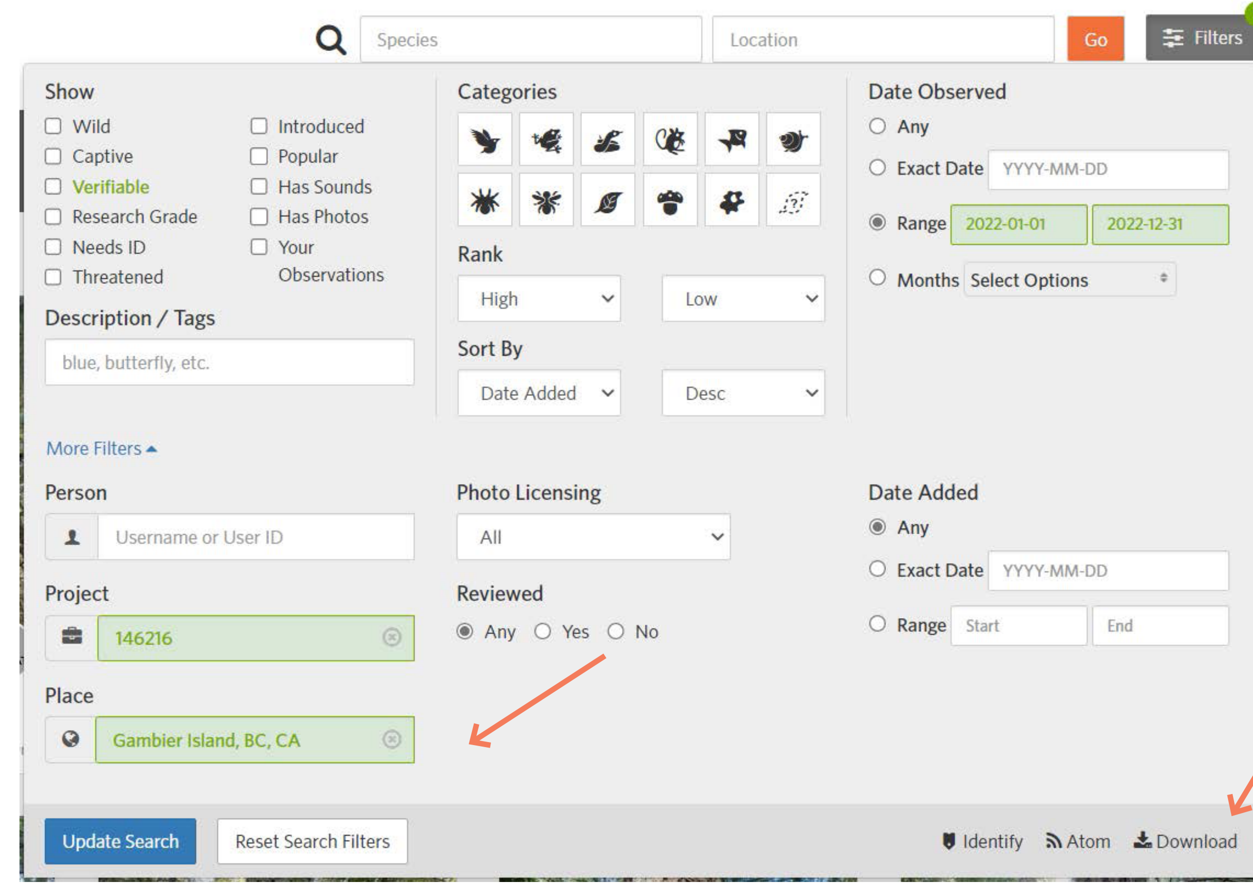
1. Go to the Traditional Project start page
2. Add your project title (required), and a project icon and cover image if you wish (optional)
3. Choose your project membership and observation submission models – if you keep things open, it's easier for people to join the project and post observations, but you'd have to do data-quality checks more frequently
4. Enter your project description (what is this project about and why are you collecting these data?)
5. Choose your project location – it is often easier to find an existing place under "iNaturalist place" (e.g., British Columbia). If your place is not on the list, you can create a new place and add it to the list
6. Decide on whether there are Observation Rules, such as whether observations must have photos or be of particular taxa
7. Add Observation Fields to the project collect monitoring data. These fields can be marked as "required" or left optional. For example, in the Large, Old Trees of BC project, CBH in centimeters is a required observation field and Tree ID Code (i.e., giving each tree a unique name) is an optional field. In a project tracking the spread of English ivy as an invasive species, the area (m2) covered by ivy can be an observation field, or the condition of the ivy patch observed (Poor to Very Good). You can add and require more than one observation field, but keep in mind that it is likely onerous for volunteers to fill in 20 observation fields for each observation they make. Only include fields you truly require information for
8. That's it for the setup! Hit "Create" to launch your project page and click on "Add Observations" to start adding data to your project
9. If you need to make changes at anytime, click on "*Edit Project*" in the top right corner of your project homepage.

Once sampling for the season is complete, data can be downloaded from the iNaturalist project for analysis. iNaturalist has a great "Filters" feature that allows you to choose particular data subsets from the overall dataset. Let's download tree measurement data collected in 2022 on Gambier Island from the Large, Old Trees of BC project.

1. On the project homepage, click on "Observations" under Stats
2. On the Observations page, click on "Filters" in the top right. You'd see "146216" under "Project," meaning the Large, Old Trees of BC project has already been pre-selected
3. In the Filters pop-up, type in "Gambier Island" under "Place" and select a date range under "Date Observed" of 2022-01-01 to 2022-12-31
4. Click "Update Search" to see the Gambier Island observations in 2022
5. To download data, click on "Filters" again and click "Download" in the bottom right of the popup
6. Under "Choose columns," make sure you select all observation fields to obtain tree size data and ID codes
7. Click "Create Export" to get a data spreadsheet that you can use to make graphs or for analysis.

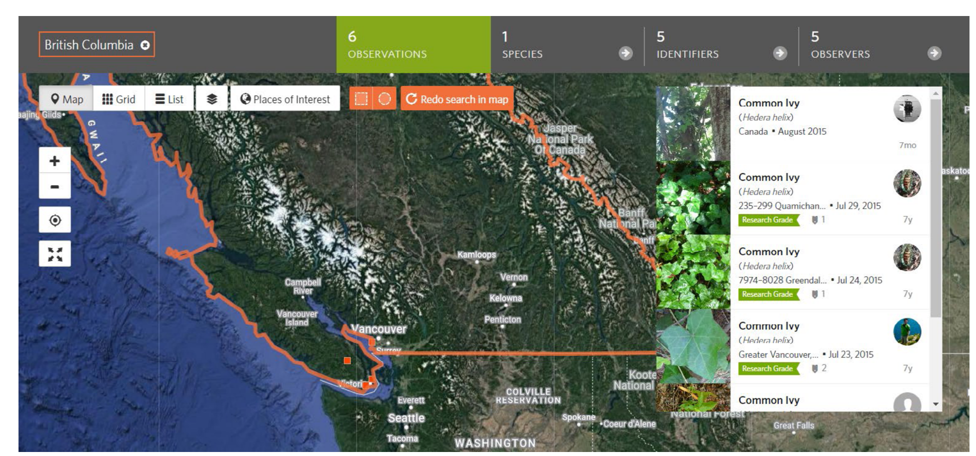


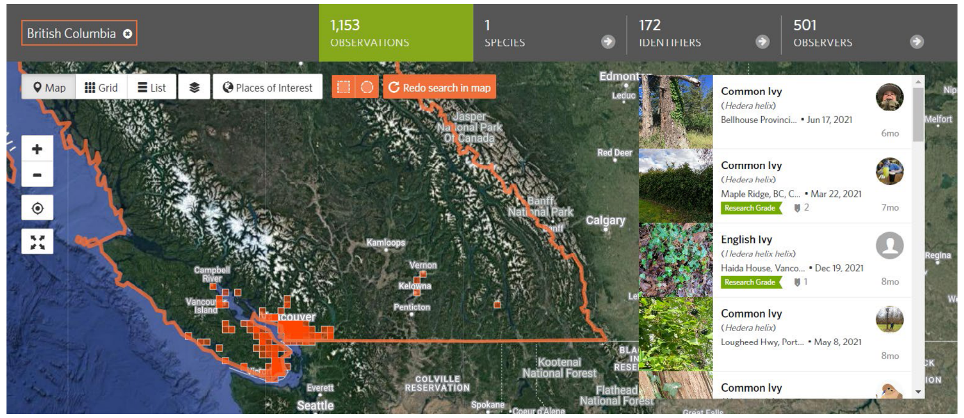




Track spatial changes over time using maps

Another cool way of using iNaturalist for monitoring is to track changes in species spatial distribution (where a certain species can be found) with maps (Box 1 Fig. 1). Each iNaturalist observation includes a location and date, so if there was an initial survey (e.g., a dedicated bioblitz) to establish the baseline distribution of a species in an area, subsequent surveys can be conducted to generate annual maps for comparison against the baseline map. This is particularly useful for tracking the spread of invasive species (plus how fast they are spreading year to year) and impacts of climate change, such as species range shifts (e.g., whether a species range is slowly expanding northward as the northerly climate warms up). To view a map of observations, choose “Map” instead of “Grid” under Observations. Use the search bar and filters as described above to select the species, place, and date range of interest or, if you had created an iNaturalist project to collate monitoring information, view observations from your project only.





Box 1 Fig. 1. A hypothetical comparison of the distribution of common ivy, an invasive plant, in BC between 2015 and 2021 using iNaturalist maps. In 2015, common ivy was only noted in the Vancouver area and southern Vancouver Island, but in 2021, there were several more observations, and common ivy had appeared to spread northwards on Vancouver Island and into the Okanagan region in BC. This comparison is hypothetical because the survey effort in both years was not the same, with far fewer people making observations in 2015. Do this type of comparisons only if your team is conducting consistent, regular iNaturalist surveys.

Box 2. Case study: developing a monitoring plan for French Creek Estuary, Vancouver Island

French Creek Estuary sits between Qualicum Beach and Parksville on the east coast of Vancouver Island, an area of high biodiversity. The estuary area is well known as a haven for eagles, with the adjoining forest featuring mature and towering trees ideal for nesting and perching. The estuary is also exceedingly productive, bringing with it rich and diverse food sources. Each year, high winds and surging waves dislodge thousands of gaper clams, tossing them on shore as a feast for hundreds of bald eagles and other wildlife. Eagles also gather here to feed on herring and hake, and French Creek sees salmon returning annually to spawn. Six bald eagle nests can be found within a 2-km radius of the estuary, verifying the importance of the estuary as a hub for eagle activity. Additionally, the forest hosts mature growth, including western red cedars over 150 years old, and is part of the globally endangered coastal Douglas-fir forest ecosystem.[1] The BC Parks Foundation acquired the property in 2022, and it is now managed by the Regional District of Nanaimo (RDN) as the French Creek Estuary Nature Preserve (interim name). Using this nature preserve as a case study, we'll walk through how to set up a monitoring program here based on the workflow laid out in the project builder form, including premonitoring considerations, indicator and protocol selection, and the data management plan. The completed project builder form can be found in Appendix 2.

Monitoring objectives

Because there is previous and ongoing research and monitoring happening in the area, baseline information is available, with a comprehensive overview available in a 2018 report[2] by the Mt. Arrowsmith Biosphere Region Research Institute (MABRRI) of Vancouver Island University (VIU). The main monitoring objective would be to track changes in habitat status via changes in target species status and habitat features, and a secondary objective would be to assess the success of invasive plant species removal measures, if they were to occur.

Funding

There is ongoing in-kind scientific and technical support from MABRRI, as well as park management and infrastructure support (e.g., signage) from the RDN. Two local conservation groups, Save Estuary Land Society (SELS) and Arrowsmith Naturalists (ANat), received mini grants (<$5000 each) from the BC Parks Foundation for community science projects covering a project period of December 2022 to April 2023. The conservation groups also apply for grants as and when the opportunity arises. There is initial funding for purchasing reusable monitoring equipment, but funding is uncertain going forward. Thus, the monitoring focus would be on **low-cost** methods.

Monitoring partners and potential monitor pools

There are five local conservation groups active in the area, including SELS and ANat, that are wellconnected with the local community and experienced with recruiting volunteers. MABRRI is also a major presence and a source of potential monitors through the VIU student population. The RDN manages the property, approves permits for events and activities at the nature preserve, and likely has staff visiting regularly for maintenance work. In terms of youth groups, there are two secondary schools in the vicinity and a Katimavik House in Nanaimo. The nature preserve lies in the unceded territory of the Qualicum and Snaw-Naw-As First Nations. With the help of the local conservation groups, there is potential for a sizeable number of volunteers (>20) engaging in monitoring annually, and **moderate effort** methods can be considered.

Indicator selection

The first step of the indicator selection process looks at the **main habitat type** in the nature preserve, which is coastal forest, located adjacent to an estuary, containing riparian area, a creek (French Creek), and wetland. The **habitat-forming taxa** are coastal Douglas fir, western red cedar, and other forest trees, and the nature preserve is known for the presence of large, mature trees. The **keystone taxon** is salmon that migrate up French Creek to spawn, and the **focal taxon** is definitely the bald eagle, which is a highly charismatic species found in large numbers here that is much beloved by the local community. Of the other bird species, the great blue heron is blue-listed in BC, and heron nests have been spotted on and near the preserve.

Based on the taxa of interest discussed above, eagles should be included in the monitoring plan. If eagle nests are being monitored, it does not take much more effort to additionally survey heron nests. A low-cost indicator for forest status can be the growth rate of the large, mature trees on site, which are important in forest ecology and for carbon storage, and are relatively easy to find and measure. For habitat features, it would be good to monitor water quality and water levels in the creek on a regular basis.

Survey protocols

An annual Christmas Bird Count takes place at French Creek Estuary, which would include eagles; thus, eagle count data can be extracted from the full count dataset each year. SELS is spearheading an eagle and heron nest-monitoring project for the east coast of Vancouver Island that would include French Creek Estuary. The observation method follows that of the Wildlife Tree Stewardship Program under the BC Ministry of Water, Land and Resource Stewardship, who launched a nest-monitoring app in 2023. For large tree growth, ANat is collaborating with MABRRI to set up forest plots in which large trees would be measured according to specifications laid out in the BC BigTree Program. While tree survey volunteers are onsite, they will also be asked to record all plant species observed on iNaturalist, to update and add to the species list in the 2018 MABRRI report.

No monitoring group has been identified to take charge of water quality and water level monitoring yet, but instructions for water quality monitoring are included as part of water monitoring kits and water level data can be obtained from the RDN's hydrometric station in French Creek, which was installed in July 2018.

Data quality control (QA/QC)

The protocols proposed here are well-established and used by several groups regionally or internationally. The Christmas Bird Count protocol was designed by Audubon and used by birdwatching groups around the world. The tree measurement and nest-monitoring protocols are based on standard methods used by BC researchers or government agencies. Similarly, water monitoring follows standard methods issued with each kit. Training is provided to nest-monitoring and tree survey volunteers by MABRRI or other experts. Finally, monitoring efforts are supervised, and the data submitted checked, by members of SELS and ANat.

[1] https://bcparksfoundation.ca/projects/parks-bank/french-creek-estuary/
[2] MABRRI (2018) French Creek Estuary: Assessment of its Historical, Community, and Ecological Values. Vancouver Island University, 51 pp.

Appendix 1: Project builder for community-based monitoring

Project location:

Date form completed:

General monitoring objectives

- Establish baseline with first surveys
- Track changes in habitat status via changes in target species status and habitat features

Other monitoring objectives

Is there preliminary information on this location?

☐ Yes, data and materials can be found in___ ☐ No

Funding details (source, amount, frequency, duration)

Monitoring partners and monitor pools

Habitat type(s)

Habitat-forming taxa

Keystone taxa | **Reason(s)**

Focal taxa | **Reason(s)**

Other taxa of interest | **Reason(s)**

Target taxa for monitoring

Target habitat features for monitoring

Biotic indicators	Equipment needed	Cost

Abiotic indicators	Equipment needed	Cost

Survey protocols

Indicator	Protocol	Sampling frequency	Monitors

Describe any QA/QC measures to be implemented

If additional resources are available,

Indicator	Reason(s)	Brief protocol	Sampling frequency	Cost	Potential monitors

Appendix 2: Project builder for community-based monitoring – case study

Project location: French Creek Estuary, Vancouver Island

Date form completed: 28 February 2023

General monitoring objectives

- Establish baseline with first surveys
- Track changes in habitat status via changes in target species status and habitat features

Other monitoring objectives

Rate the success of invasive plant species removal measures
Rate the success of habitat restoration – creek bank, wetlands

Is there preliminary information on this location?

☐ Yes, data and materials can be found in___ ☐ No

A 2018 report by Mount Arrowsmith Biosphere Region Research Institute (MABRRI)*, which is a comprehensive overview. There is previous and ongoing research/monitoring for this area.

*MABRRI (2018) French Creek Estuary: Assessment of its Historical, Community, and Ecological Values. Vancouver Island University, 51 pp.

Funding details (source, amount, frequency, duration)

Ongoing in-kind scientific and technical support from MABRRI. Park management and infrastructure support from the Regional District of Nanaimo (RDN). Two mini grants (<$5000 each) from the BC Parks Foundation for community science projects covering a project period of December 2022 to April 2023. Additional grants to be applied for as and when opportunities arise (future funding uncertain).

Monitoring partners and monitor pools

- Conservation groups: Save Estuary Land Society (SELS), Arrowsmith Naturalists (ANat), Friends of French Creek Conservation Society, Mid-Vancouver Island Habitat Enhancement Society
- Research group: MABRRI, Vancouver Island University (VIU) – staff and university students may participate in monitoring projects
- Government: RDN
- First Nations: Qualicum and Snaw-Naw-As First Nations
- Schools and youths: Ballenas and Kwalikum Senior Secondary Schools, Kativamik

Habitat type(s)

- Main habitat: Coastal forest adjacent to estuary
- Other habitats and subhabitats: Douglas fir/dull Oregon grape forest, riparian forest, creek, wetland

Habitat-forming taxa

Coastal Douglas fir, western red cedar; large, mature trees

Keystone taxa	Reason(s)
Salmon (chum and coho)	Recycle marine nutrients into the forest

Focal taxa	Reason(s)
Bald eagle	Substantial and highly visible population here. Charismatic species. This area has been designated as an eagle sanctuary.

Other taxa of interest	Reason(s)
Gaper clam	Main food item of eagles
Migratory birds	Attract interest from birdwatchers
Herring	Herring spawning in spring attracting several predators
Marbled murrelet, great blue heron, and other birds at risk	Threatened under Species at Risk Act, blue-listed (special concern) in BC; species at risk

Target taxa for monitoring

- Bald eagles. Eagle-nest monitoring has been taking place for 20+ years by a dedicated volunteer. Annual Christmas Bird Count (including migratory birds) and Brant Geese count hosted by Arrowsmith Naturalists are already taking place; thus, bird count expertise present in this community
- Great blue herons – 3 nests were observed on site in 2022
- Large, old trees (>1 m diameter at breast height [DBH]) – significant for carbon storage, visible, relatively easy to find and measure
- Juvenile fish in creek pre- and post-restoration, engage in planning as part of restoration project

Target habitat feature(s) for monitoring

Water quality in the creek and estuary, water levels in the creek; pre- and post-restoration

Biotic indicators	Equipment needed	Cost
1. Eagle abundance	Binoculars, ID guide, datasheets & clipboards	<$100/year if volunteers provide own binos (~$100 each)
2. Eagle and heron nests – number, location, productivity	Binoculars, ID guide, datasheets & clipboards	<$100/year if volunteers provide own binos (~$100 each)
3. Large tree size, number and location	Measuring tape, DBH stick, datasheets & clipboards, GPS	<$100/year, ~$300/GPS
4. Species richness	Camera/smartphone, iNaturalist	Free (volunteer provided)
Abiotic indicators	**Equipment needed**	**Cost**
5. Water quality parameters (salinity, fecal coliform, dissolved oxygen [DO], temperature, pH, turbidity, nitrate, phosphate, chlorophyll)	Water monitoring kit, sampling bottles, gloves, safety glasses	~$120/year for estuarine water, $70/year for freshwater
6. Water level in the creek	CrowdWater app, smartphone There is a hydrometric station installed in French Creek by RDN in July 2018	Free

Indicator	Protocol	Sampling frequency	Monitors
1.	As part of Audubon Christmas Bird Count	Once a year, around December	Bird Count volunteers
2.	Follow observation protocol of the Wildlife Tree Stewardship Program under the BC Ministry of Water, Land and Resource Stewardship. Record using the nest-monitoring app	During spring nesting season (February-April)	Recruited from the public by SELS
3.	Measure circumference of tree at breast height. Note tree species and take a photo of the tree. Record GPS coordinates of each large tree measured	Once a year	VIU students and volunteers recruited from the public by ANat
4.	Have volunteers record all species in the area on iNaturalist to generate a species list, add to 2018 MABRRI list	During large tree measurement visits	VIU students and volunteers
5.	Collect water at each station using sampling bottles. Follow kit instructions for each variable	Monthly is ideal	TBD
6.	Use the CrowdWater app to place a virtual gauge in the creek and record water levels and dates subsequently or obtain data from RDN	Opportunistic/daily	Public/RDN

Describe any QA/QC measures to be implemented

The Christmas Bird Count protocol is well established (by Audubon) and used globally. Tree measurement, nest-monitoring and water quality monitoring methods follow standard protocols used by regional authorities or other monitoring programs. Training is provided to nest-monitoring and tree survey volunteers by MABRRI or other experts. Monitoring efforts are supervised, and data submitted checked, by members of SELS and ANat.

Indicator	Reason(s)	Brief protocol	Sampling frequency	Cost	Potential monitors
Freshwater macroinvertebrates in creek	Indicator of freshwater quality	Set out leaf litter bags or systematic sampling of creek bed following instructions in water quality monitoring kit; dissecting microscopes useful	Once during spring, summer, and fall or once a year during late spring/early summer	<$100-200/year	Would be a good classroom activity
Forest, estuary vegetation cover	Habitat-forming taxa	Extract areal cover from satellite images	Annually	Depends on extraction method	Someone trained in image analysis
Presence and timing of wet/dry streams	Monitor drought conditions	Use CrowdWater app to record	Opportunistic	Free	Public
Gaper clam density	Linked to eagle population status	Count clams on shore when eagles are present or dig up quadrats during low tide	Monthly when eagles present or once a year for quadrats	<$100/year	Conservation group volunteers

Indicator	Reason(s)	Brief protocol	Sampling frequency	Cost	Potential monitors
Herring spawning timing, presence	Important food for several predatorss	Report herring activity through the Herring Watch app or iNaturalist; or extract spawning areal cover from satellite images	Opportunistic (public) or daily during spawning season (satellite)	Ads and signage during spawning season; image analysis tools	Public; image analysis technician
Spawning salmon timing, presence, abundance	Keystone taxon	Follow Streamkeepers protocol	Once a week during spawning season	<$100/year but time intensive	Conservation group volunteers
Invasive species abundance and location	Considered one of the primary ecological threats	Create map (via iNaturalist?) for future removal events	Opportunistic, perhaps include a BioBlitz	Free	Public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